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Understanding EDGE Technology for mobile design

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Innovating the HP Way

EDGE (Enhanced Data GSM Evolution)

Outline

I. **What is EDGE?**
II. **Design changes in EDGE mobile**
III. **EDGE Testing Challenges**
IV. **Mfg considerations**

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I. What is EDGE? (Enhanced Data GSM Evolution)

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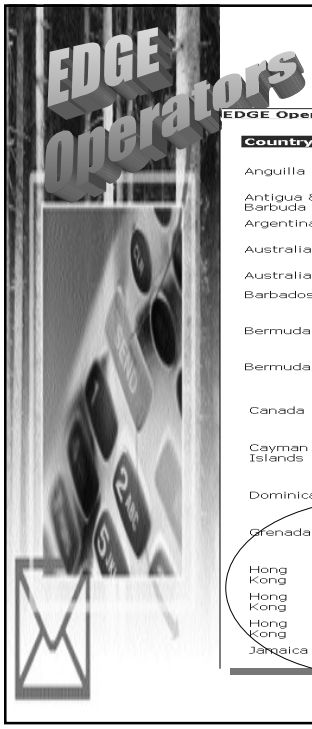
EDGE Business Potential ?!



http://www.gsmworld.com/technology/edge/operators.shtml

EDGE Operators

Country	Operator	Status	Country	Operator	Status
Anguilla	Cable & Wireless	Planned	Mexico	Telcel	Planned
Antigua & Barbuda	Cable & Wireless	Planned	Singapore	StarHub	Planned
Argentina	Telecom Personal	Planned	Montserrat	Cable & Wireless	Planned
Australia	Telstra	12/2004	St Kitts & Nevis	Cable & Wireless	Planned
Australia	Optus	Planned	St Lucia	Cable & Wireless	Planned
Barbados	Cable & Wireless	Planned	St Vincent & The Grenadines	Cable & Wireless	Planned
Bermuda	Telecom	Q1-Q2/2003	Turks & Caicos Islands	Cable & Wireless	Planned
Bermuda	The Bermuda Telephone Company	Planned	Singapore	StarHub	In Trial
Canada	Rogers AT&T Wireless	03/2004	USA	AT&T Wireless Group	Deployed
Cayman Islands	Cable & Wireless Cayman Islands	Planned	USA	Cingular Wireless	Deployed
Dominica	Cable & Wireless Dominica	Planned	USA	Dobson Communications	Deployed
Grenada	Cable & Wireless Grenada	Planned	USA	T-Mobile USA	Deployed
Hong Kong	Peoples Telephone	Planned	Kuwait	Wataniya Telecom (NMTC)	Q1 2004
Hong Kong	Hong Kong CSL	In Trial			
Hong Kong	Sunday	In Trial			
Jamaica	Cable & Wireless	Planned			

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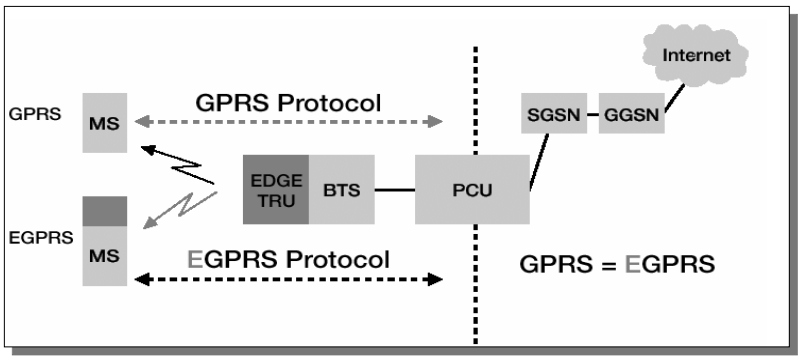
EDGE As An Evolution Path to 3G

- EDGE was first proposed to ETSI
- Feasibility study was completed in 1997 and approved by ETSI
- EDGE satisfies the 384 kbps data rate requirement.
- It is a radio interface improvement but can be thought of as a system concept that allows both GSM and GPRS to offer new services (i.e. higher data rates and multimedia)

EDGE Architectures



EDGE does not bring about any direct architecture impacts (GSM 03.60)

EGPRS=Enhanced GPRS
BTS=Base Station
MS=Mobile station
GGSN= Gateway GPRS support node
SGSN= Serving GPRS support node
PCU=Packet control unit
TRU=Transceiver unit

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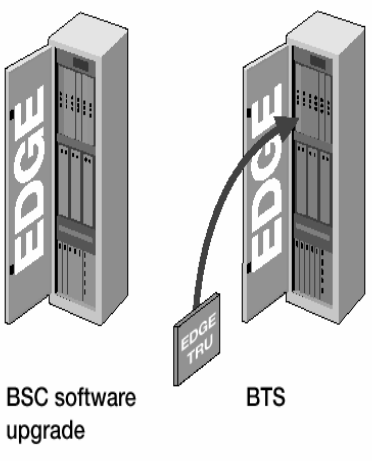
EDGE Architectures & Interfaces



EDGE Outdoor Base Station

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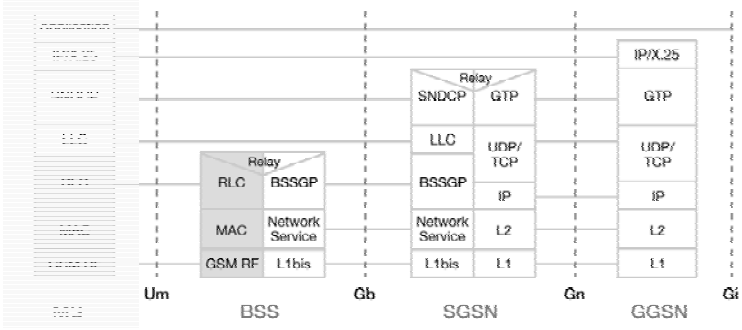
User Plane Protocols (Not much changes!)



- The protocols that are influenced by the introduction of EDGE are shaded.
- The protocols closest to the physical layer (the radio link control and mobile allocation channel) are most affected by EDGE (GSM 04.60).
- There also are some minor modifications to the base station system GPRS protocol. Apart from these changes,the rest of the protocol stack remains intact after the introduction of EDGE.

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Changes!! Air Interface

- GMSK modulation is maintained for certain data rates
- 8-PSK modulation with $3\pi/8$ rotation per symbol is used for higher data rates
- TS format is maintained for backward compatibility and easier design
- Symbol rate is the same as in GSM (270.833 ksps)
- For 8-PSK modulation, the raw bit rate is tripled

  (3x270.833 = 812.499 kbps)

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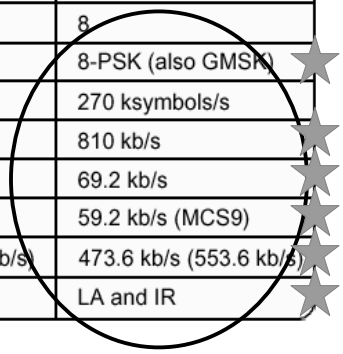
Physical Layer: GPRS / EDGE Comparsion

Parameter	GSM/GPRS	EDGE
Carrier spacing	200 kHz	200 kHz
Frame length	4.6 ms frames	4.6 ms frames
Timeslots per carrier	8	8
Modulation	GMSK	8-PSK (also GMSK)
Symbol rate	270 ksymbols/s	270 ksymbols/s
Modulation bit rate	270 kb/s	810 kb/s
Radio data rate per time slot	22.8 kb/s	69.2 kb/s
Max. user data rate per time slot	20 kb/s (CS4)	59.2 kb/s (MCS9)
Max user data rate - 8 time slots	160 kb/s (182.4 kb/s)	473.6 kb/s (553.6 kb/s)
Link Quality Control (LQC)	None	LA and IR



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How It is Different (continued)

- After a certain operating point (SIR level), GPRS transmission rate saturates. So, EDGE introduces a new modulation scheme (8-PSK) to drive data rates higher.
  - This gives three bits per symbol as compared with one bit per symbol for GSM
- With this modulation, EDGE supports higher data rates for packet-switched services with EGPRS.

8-PSK

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Modulation and Coding Rates for EDGE

- **8-PSK added for higher data rates**

MCS	Modulation	Code Rate	Bit Rate /Timeslot
MCS-1	GMSK	0.53	8.8
MCS-2		0.66	11.2
MCS-3		0.8	14.8
MCS-4		1	17.6
MCS-5	8-PSK	0.37	22.4
MCS-6		0.49	29.6
MCS-7		0.76	44.8
MCS-8		0.92	54.5
MCS-9		1	59.2

What is 8-PSK?

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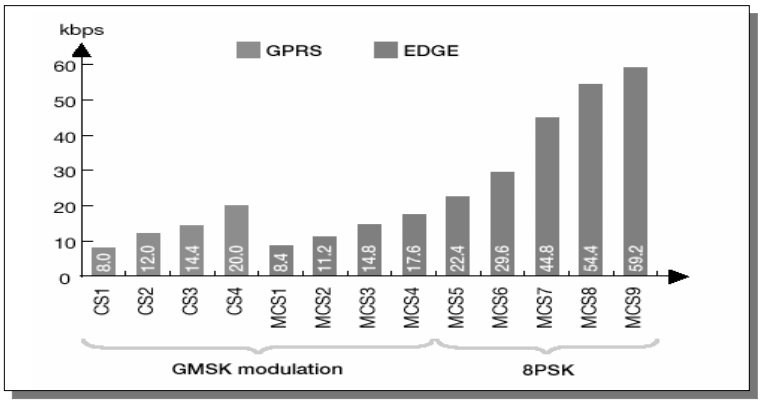
Coding Scheme Comparison



•The graph shows both GPRS and EDGE coding schemes with their max. throughputs.

• GPRS user throughput reaches saturation at a maximum of 20 kbps with CS4,

• EGPRS bit rate continues to increase as the radio quality increases until 59.2 kbps.

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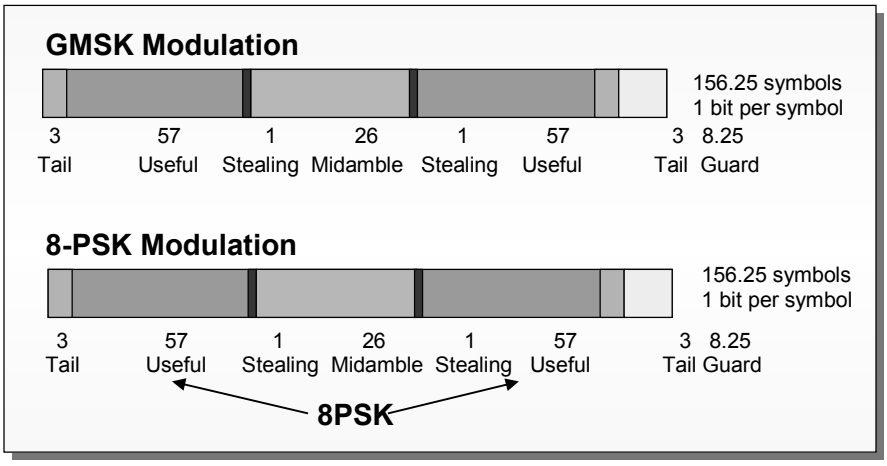
Air Interface - Time Slot Format



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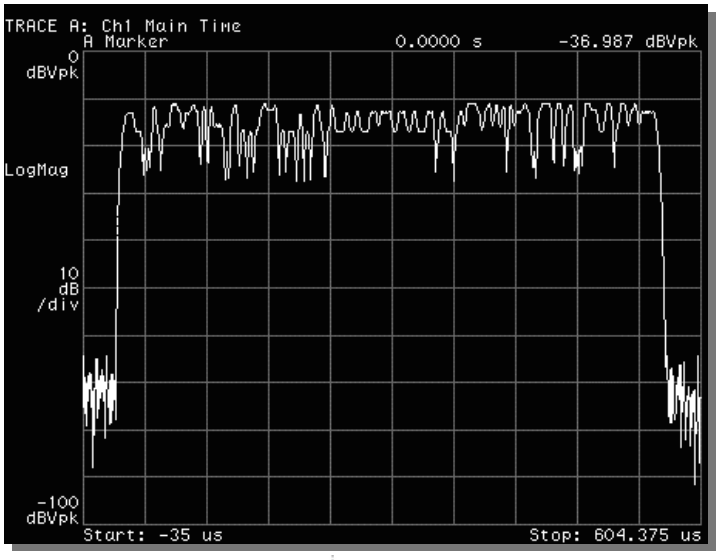
Air Interface - Time Slot Format



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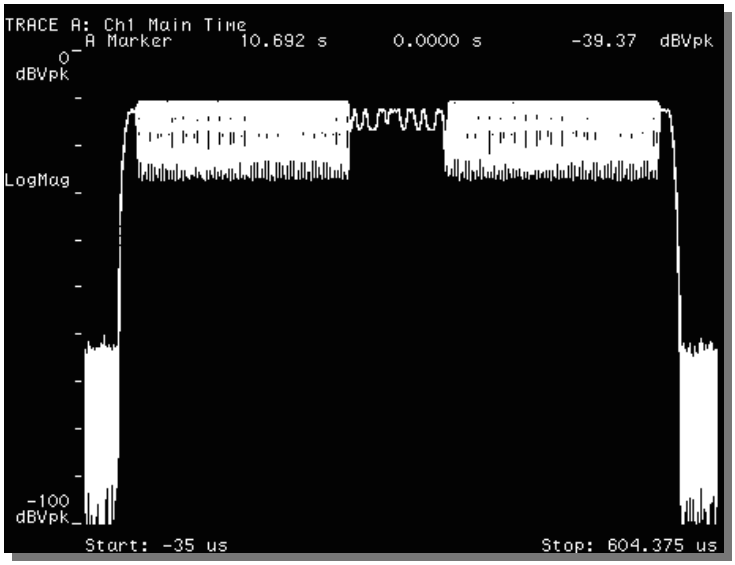
Air Interface - Time Slot Format



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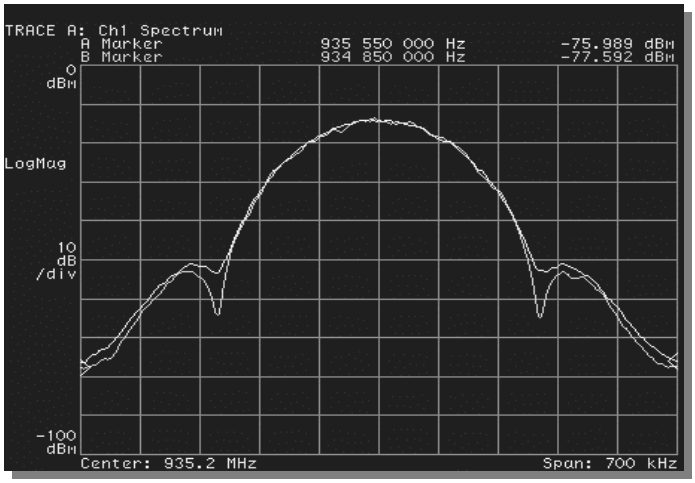
Air Interface - Spectrum

- EDGE is spectrum compatible with GSM, i.e. it uses the same 200 kHz channel spacing



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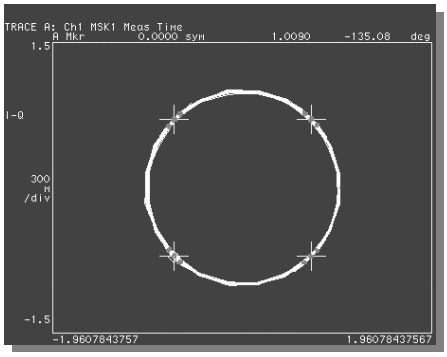
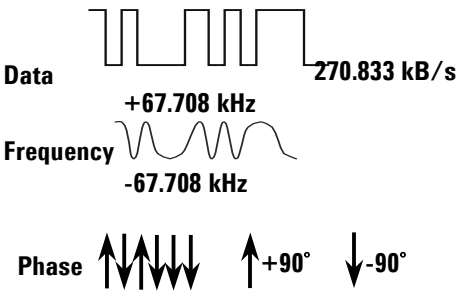
GSM Air Interface

- Uses 0.3GMSK modulation: 1 bit/symbol
- Constant envelope
- 200 kHz channel bandwidth





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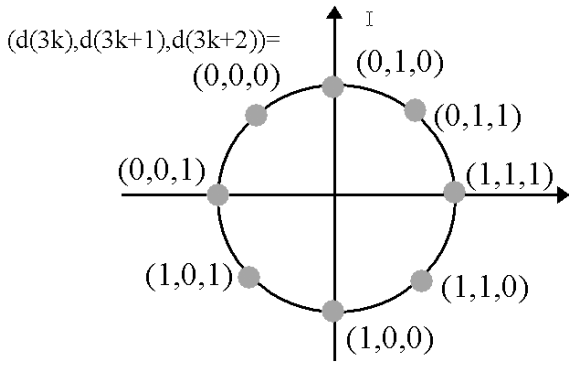
EDGE Air Interface - Modulation

- 8-PSK modulation is used for high data rates
- Signal trajectory will pass through the origin
- High peak-to-average ratio



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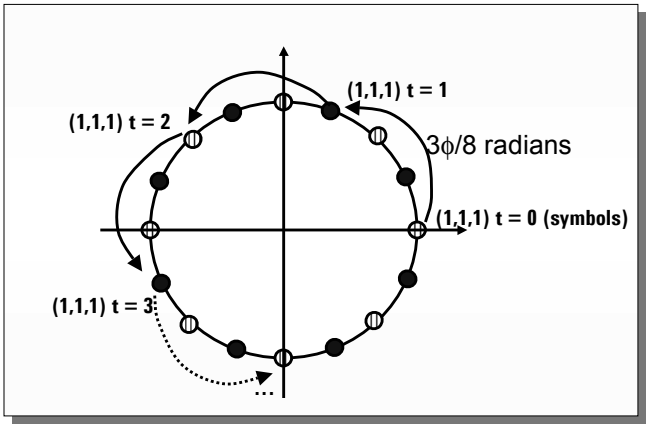
EDGE Air Interface - Modulation

1. 8-PSK constellation rotates 3ϕ / 8 radians per symbol period
2. Rotation prevents zero crossings, reducing peak-to-average power



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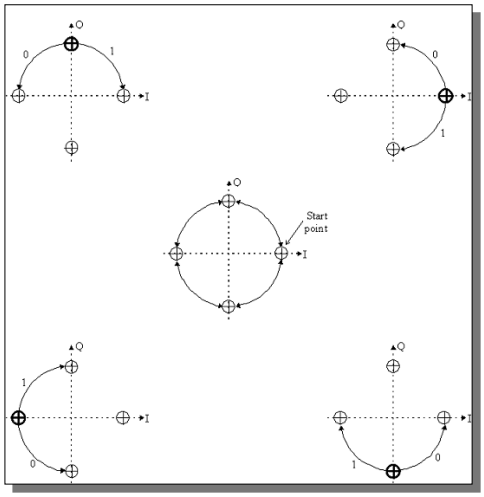
GMSK Modulation constellations

1. EDGE coding schemes MCS1-4 (this is not the same as GPRS CS1-4)
2. Uses GMSK modulation
3. 1 bit per symbol
4. Constant power trace



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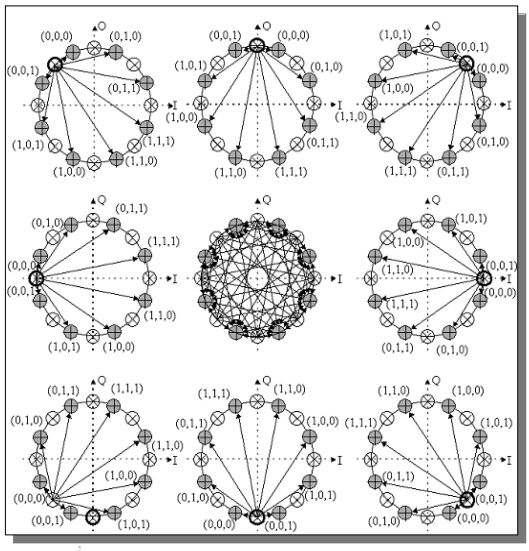
3ϕ/8 8PSK Modulation Constellations

1. EDGE coding schemes MCS5-9
2. Uses 3ϕ/8 8PSK
3. 3 bits per symbol
4. Utilises a 3ϕ/8 rotation every symbol to avoid zero transitions
5. Power trace now varies with symbol transitions



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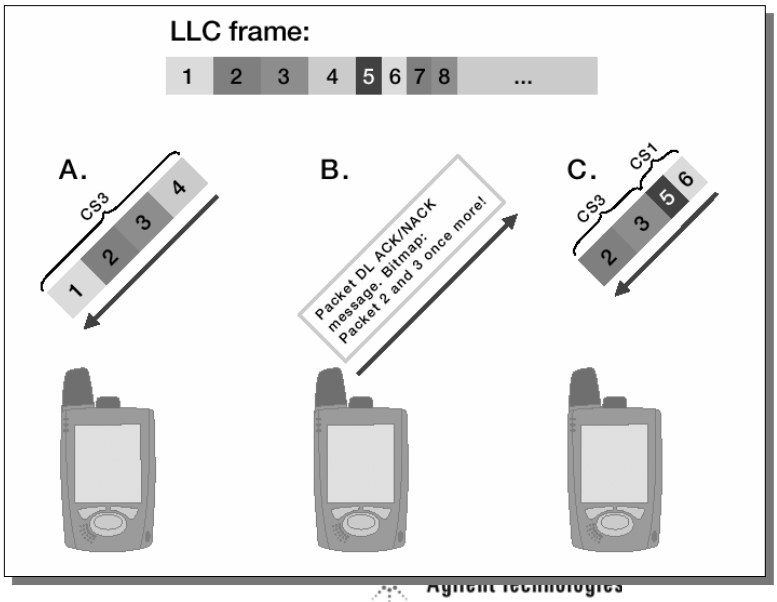
EDGE :Packet Handling



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EDGE: Packet Handling

- Another improvement that has been made to the EDGE standard is the ability to retransmit a packet that has not been decoded properly with a more robust coding scheme.
- For GPRS, re-segmentation is not possible.
- Once packets have been sent,they must be retransmitted using the original coding scheme even if the radio environment has changed.
- This has a significant impact on the throughput,as the algorithm decides the level of confidence with which the link adaptation (LA) must work.

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Link Quality Control:

LA (Link Adaptation)

– select the MCS that gives a maximum throughput for certain C/I

IR (Incremental Redundancy)

– Packet is sent with a certain puncture scheme

– If a packet is received in error, the transmitter will retransmit the packet with another puncture scheme

– at the end all the packets will be combined (better performance)

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Link Adaptation.

Channel Coding schemes	Throughput/TS	Family	
MCS9	59,2	A	GMSK
MCS8	54,4	A	
MCS7	44,8	B	
MCS6	29,6	A	
MCS5	22,4	B	8PSK
MCS4	17,6	C	
MCS3	14,8	A	
MCS2	11,2	B	
MCS1	8,8	C	

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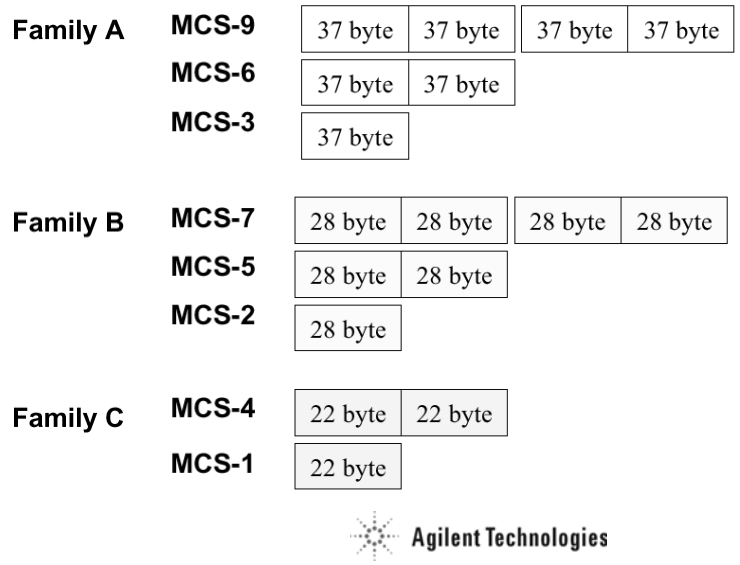
Link Adaptation.



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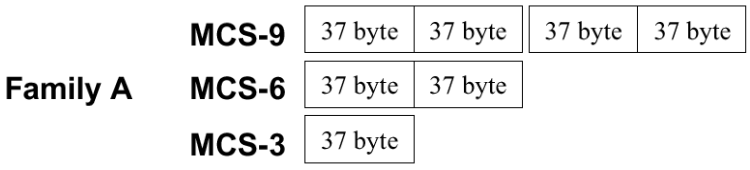
Link Adaptation.



Example

- **MCS-9 carries 2 RLC blocks @ 74 byte each**
- **Retransmission using MCS-6**
- **For further retransmission, 74byte block will be segmented into 2 x 37 blocks MCS-3.**

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Incremental Redundancy

The purpose of incremental redundancy is to increase throughput by minimising the amount of redundant data sent OTA by:

- Only sending redundant data when necessary by use of ARQ (Automatic Repeat Request) protocol
- Retransmitting more redundancy by transmitting the ***same data*** with a ***different puncturing schemes***
- Data is combined from original and retransmitted blocks to increase likelihood of correctly decoding blocks
- MCS family groups are arranged such that data can be sent at high MCS and retransmitted in parts at lower MCS (retransmissions in GPRS must be at same CS)

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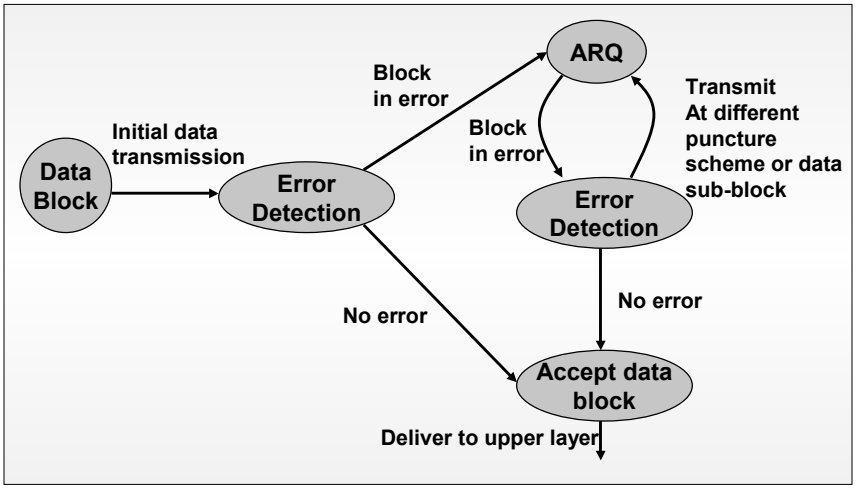
Incremental Redundancy

•State diagram for IR



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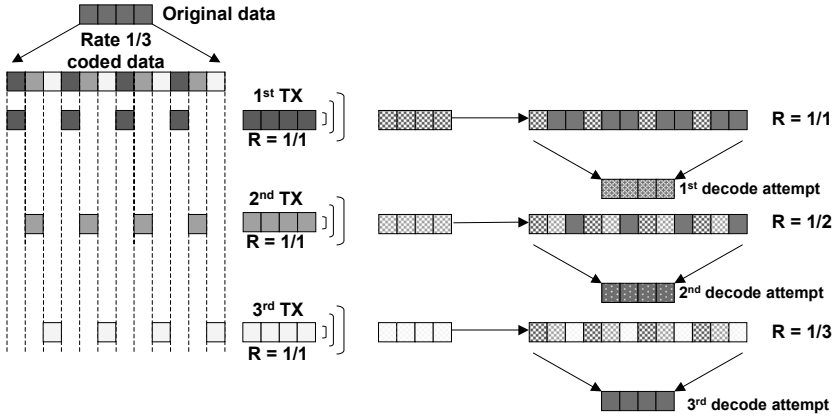
Incremental Redundancy – Example using MCS-9

- The original data is 1/3 coded and then punctured in three ways. The first TX is sent if in error 2nd is sent and combined with the first increasing redundancy and so on with the third, by which time the 1/3 redundancy is reproduced



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Incremental Redundancy – Retransmission using different coding Schemes

- In EGPRS it is possible for data to be retransmitted using a different coding Scheme.
- These retransmissions must use coding schemes from the same family
- There will be segmentation between coding schemes of same family
- When using MCS-8 it is necessary to add padding to data, as padding is added before the channel coding incremental redundancy recombining is not possible

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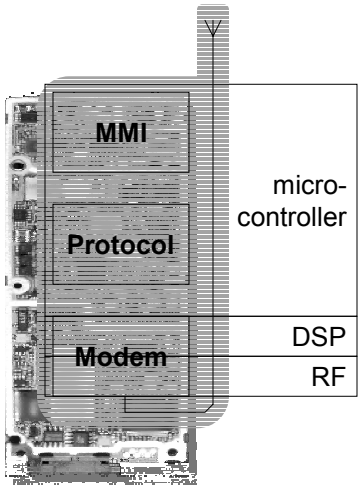
II. Design Challenges in EDGE Mobile



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EGPRS design considerations (DATA)

All of the considerations which previously applied to GPRS also apply to EGPRS.

- Multi-slot down and uplink,
- Faster LO and PLL settling then GSM
- MIPS – Faster data rates, Power consumption & Thermal issues
- DSP decode algorithm and prediction – has to be more robust, more MIPS (approx. factor of 4), more memory, more data retention (Incremental Redundancy)
- New user capabilities - graphics acceleration and display

(TTP.COM) "EDGE will require up to 400 MIPS using 4 Slots."

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EGPRS design considerations (RF)

There are also new or more complex considerations

for 8PSK and EGPRS:

- (TX) Amplifier linearity, efficiency - thermal/battery again, but this time MUCH worse
- (TX) Modulation Quality – EVM/Phase error/Frequency error
- (TX) Filter changes between GMSK and 8PSK,

  but (almost same) ORFS emission mask
- (RX) Receiver must now demodulate both GMSK and 8PSK, perhaps in contiguous bursts – 8PSK S/N - BER/BLER demodulation challenges

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EGPRS design considerations (Modulation)

1. **Linearity of modulation (GSM/GPRS)**
   - how do we preserve phase and amplitude information when radio components (e.g. power amplifiers) introduce distortions of their own?
   - GSM transmitters have been optimised to deliver 'high' efficiency and low noise at low cost

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EGPRS design considerations (Modulation)

2. Non-Linearity of modulation (EDGE)

- with EDGE, overcome non-linearity by using (1) feedback or (2) pre-distortion or (3) both
- most techniques require a complex mixer...
- which requires a duplexer...
- which was actively designed out of GSM handsets to remove size, weight, cost and power inefficiency!

DESIGN TIPS (GSM/GPRS/EDGE phone)

•careful design of the transmit path is needed

•new power control-loop is required

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EGPRS TEST considerations

There are also new test considerations for EDGE

- New 8PSK modulation format requires validation
- Modulation Quality – EVM/Phase error/Frequency error
- 8PSK Power measurement changes
- Power Vs Time – New mask definition
- ORFS – More challenging to meet the same specification
- Testing under multiple TX timeslots

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EGPRS TEST considerations

There are also new test considerations for EDGE

- Receiver must now demodulate 8PSK - BER/BLER
- New Test Connection type – SRB
- Possible asymmetric coding schemes
- Some devices will be 8PSK Downlink ,and GMSK uplink

  –how does loop-back BER/BLER operate?
- MIPS, application, memory, network latency, delays, IR protocol complexity
- Testing under multiple timeslots

EDGE RX Testing

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III.

EDGE Testing Challenges

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Measurement Comparison

	GSM/GPRS GMSK	EGPRS 8PSK
Output Power over useful part of burst	Not data dependent	Use Random Data
Spectrum due to Modulation	Yes	Different Mask (one point only, 4dB@400KHz)
Spectrum due to Switching	Yes	Same as MSK
Spurious	Yes	Same as MSK
Power Vs. Time	Yes	Different Mask
Modulation Accuracy	Phase Error: Peak and RMS	EVM: Peak, RMS, 95th% Origin Offset

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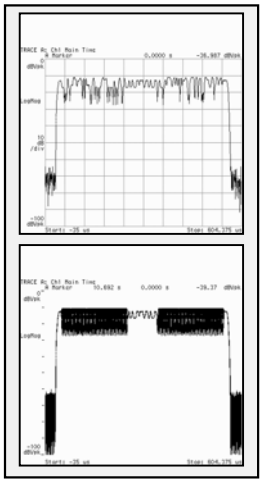
Measurements – Tx Power and Power Vs Time

- GMSK power variation through burst is minimal – simple to measure, independent of data
- 8PSK EGPRS power variation considerable – requires random data, much larger variation, and has to be averaged – OR predicted.
- Agilent 8PSK FAST TxP measurement uses modulation information to effectively calculate the averaged Tx Power with *ONE* burst.



TXP & PVT Measurement

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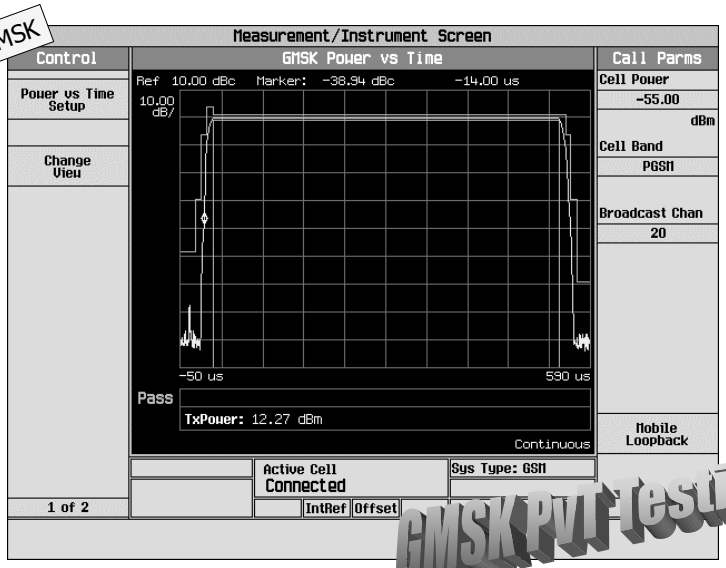
Measurements – Tx Power and Power Vs Time

GMSK



GMSK PVT Testing

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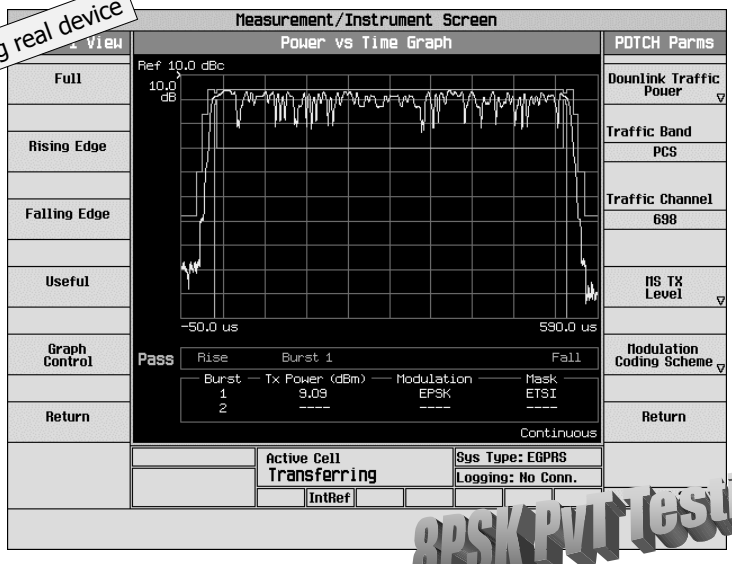
Measurements – Tx Power and Power Vs Time

8PSK using real device



8PSK PVT Testing

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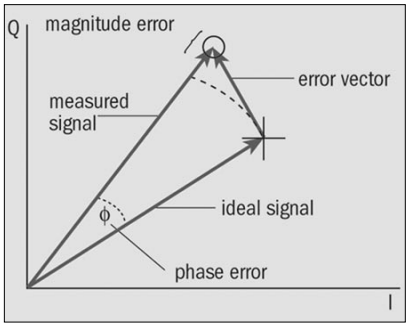
Measurements – PFER vs Mod Acc

- GMSK PFER - Constant amplitude, simple phase rotation, phase and frequency measurement
- EDGE 8PSK Modulation Accuracy
  - Amplitude component added to phase component to give Error Vector Magnitude
  - 95th percentile EVM measurement
  - IQ Imbalance, amplitude droop through burst



Mod Acc Measurement

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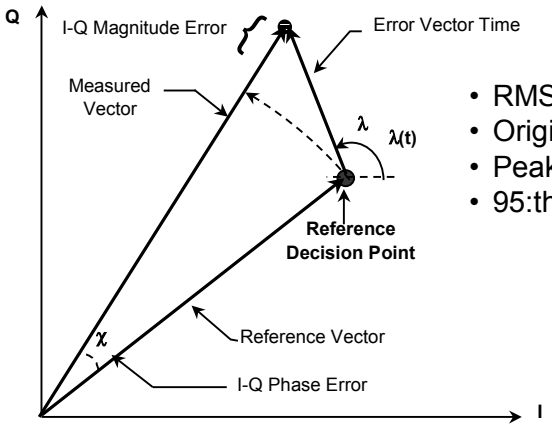
EDGE - Error Vector Magnitude



- RMS EVMΩ9%
- Origin offset suppression Ω30 dB
- Peak EVM Ω30%
- 95:th-percentile EVM Ω15%

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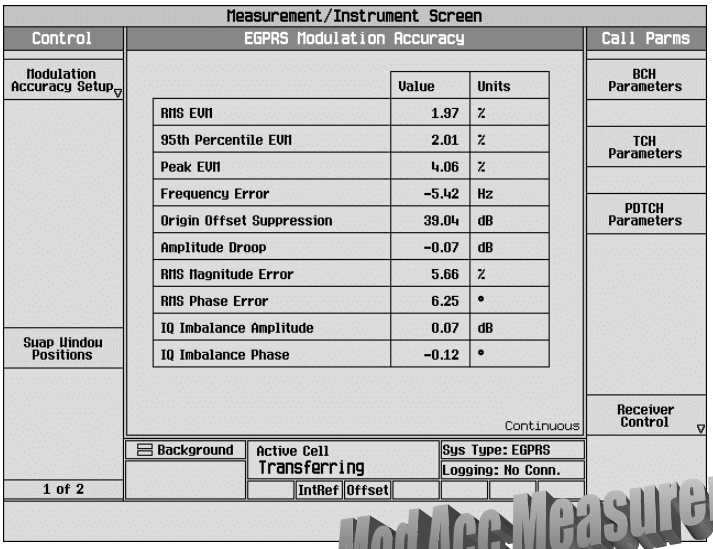
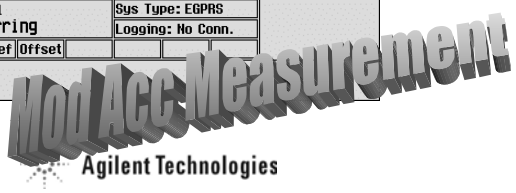
Measurements – Mod Acc





Measurements – BER/BLER

Bit Error Rate (BER)

- Instrument sends data to device, device loops back data, sent/received data is compared in instrument and BER calculated

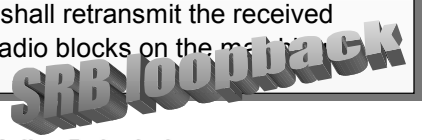
BLER - 2 methods

- BLER Measurement Reports - device is polled and reported ACK/NACK's displayed
- BLER Measurement - BLER is derived from the BER results

Measurements – BER/BLER

- EGPRS can have different modulation formats (GMSK/8PSK) on uplink and downlink
- Not generally practical for manufacturing test, and does not need to be used, except when only GMSK transmission is available on the uplink.
- In this case **3GPP TS 04.14 V8.4.0 (2002-07), R99, Sec 5.5.4** Describing the operation of SRB defines that:

  "If the uplink TBF was established using a GMSK modulation scheme, and the downlink is 8PSK modulated, a radio block sent by the SS on a downlink timeslot using 8PSK modulation should be followed by two radio blocks on the same timeslot where the SS does not transmit any data. The MS shall retransmit the received 8PSK data over the following three radio blocks on the matching uplink timeslot"



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Data Connection Type - SRB

- EGPRS has no "clear-coded" coding Schemes – Even MSC4, 9 have error correction
- Switched Radio Block Loop-back mode (SRB) - Loops back data before decoding – downlink data is sent back on the uplink
- Unlike ETSI test Mode B – no MS interpretation or correction of the raw data
- THE preferred EGPRS RF test data connection type
- SRB must be supported by the MS

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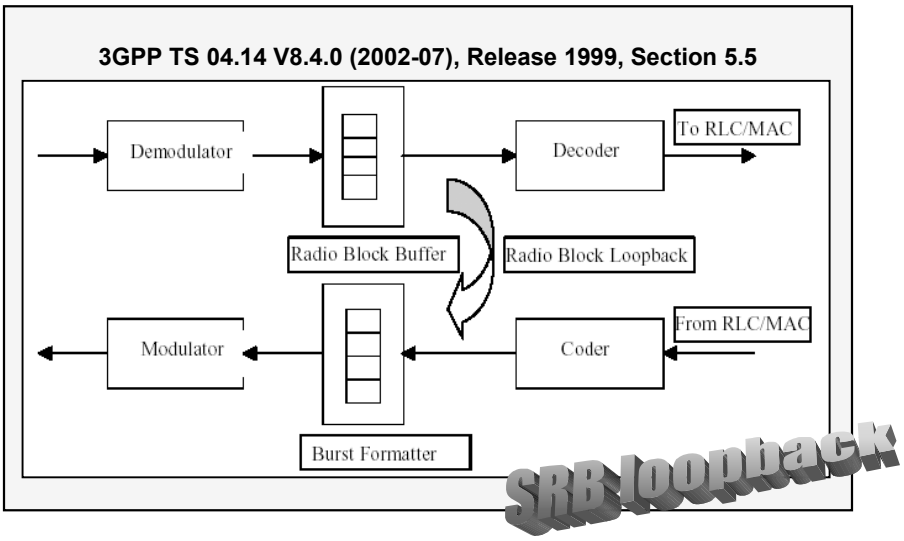
Data Connection Type - SRB



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Data Connections – Agilent BLER

How does Agilent BLER operate, why does this affect 8PSK measurements?

- 1. A "Packet Downlink Assignment" message assigning the selected timeslots is sent to a previously attached mobile station.
- 2. A GPRS Mobility Management (GMM) information message containing none of the optional information elements (that is, a GMM information header only) is sent via the lower protocol stack layers (LLC & RLC/MAC) to the mobile station every block in all active timeslots of the assigned downlink channel. A complete message can be sent in one block, and is repeated every block.

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Data Connections – Agilent BLER

How does Agilent BLER operate, why does this affect 8PSK measurements?

- 3. To generate a measurable uplink, the mobile station is polled every block (every block is default - poll rate is user settable) on the demodulating timeslot. This causes the mobile station to transmit on the downlink TBF PACCH logical channel a "Packet Downlink Acknowledged/Not Acknowledged" message that contains the BLER information.
- BLER connection type was very helpful for GPRS mobiles which did not support ETSI A or B test modes. It can still be used for EGPRS, BUT the ACK/NACK's are always transmitted in GMSK.
- BLER can therefore be used for 8PSK demod, BLER tests and GMSK transmitter measurements, but NOT 8PSK Tx Measurements.

BLER loopback

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IV.

EDGE Manufacturing Considerations

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1.GSM/GPRS/EGPRS Test Strategy

■**1. Testing GSM only, do not test GPRS/EGPRS**
- There are many changes in physical layers in GPRS.
  (e.g. PLL/LO timing, 2 uplink PvT testing, Block Error Rate…..)

■**2. Testing GSM & GPRS & EGPRS in 2 separate testers**
- Waste of handling time, power on/off & camping time,…….
- GSM & EGPRS testings are very similar.

■**3. Combination GSM & EGPRS testing together**

NO GPRS testing required
- Saving the overall testing time
- Testing the switching between GSM (Voice) & EGPRS (data)
- **EGPRS will cover GPRS testing.**

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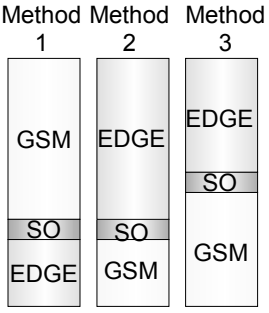
GSM/EDGE Test Strategy

■**Combination GSM & EGPRS testing together**
- Target Test time = 1.5X (comparing with existing GSM test plan)

■**Different Testing Strategies**

1. GSM (Major test) + EGPRS (Minor)
2. EGPRS (Major test) + GSM (minor)
3. GSM (50%) + EGPRS (50%)



SO= Switching Over

■**Different Testing conditions**

New GPRS testing items
- Slot Configurations: 1x1, 2x1,3x1, 4x1, 2x2, 3x2
- Modulation Coding Scheme: MCS1-4 (GMSK)
- MCS5-9 (8PSK)
- Uplink & Downlink MCS BLER testing.

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GSM/GPRS Test Strategy

■**Typical GSM Test plan**

- Under dual-band or tri-band mode
  Lower Channel : TX + RX tests
  Middle Channel: Major TX tests
  Upper Channel: TX + RX tests

When designing a Combined GSM/EDGE testing:

Notes: 1. EGPRS can cover most of TX tests in GSM
2. GSM is under 1x1.
3. New MCS testing requirement
4. New Modulation Accuracy testing requirement

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Agilent Test Solution Provides Efficient RF Conformance of W-CDMA Handset

Agenda

Requirements for RF Parametric Test Solutions

Agilent Test Solution Family

Technical Issues in RF Parametric Test

Examples of Techniques Employed in GS-8800

Conclusion

Requirements for RF Parametric Test Solutions

Support of multiple radio technologies on the same hardware platform

- **GSM/GPRS/EGPRS/W-CDMA/cdmaOne/cdma2000/1xEV-DO**
- **Software radio design approach will save hardware cost and increase investment return**

Accelerates I&V cycles and TTM

- **Fast test speed**
- **Easy to use (turnkey solution)**
- **More than just conformance - good design verification capability for R&D**

Agilent Handset Test Solution Family

Z2195A W-CDMA RF Full Conformance System

- 3GPP TS 34.121 Subclause 5, 6, 7 and 8
- UMTS UE and NTT DoCoMo W-CDMA (FOMA)
- Max 6 Cell Simulation
- Soft Handover and Frequency Hard Handover with Compressed mode
- Supported band: Band I
- Two protocol tester as system simulators
- 1M – 2M$

GS-8800 RF Design Verification System

- W-CDMA, GSM/GPRS/EGPRS and c2k/1xEVDO
- All test cases of 3GPP TS 34.121 Subclause 5-7.5
- Function test of Soft Handover and W-CDMA/GSM Hard Handover
- Supported W-CDMA band: All Bands (I, II, III, IV, V, VI)
- High speed test using E5515C RF Comm Test Set.
- GCF/PTCRB Certification (Planned in September)
- 300k – 800k$

- Almost all Radio technologies including AMPS
- Parallel testing of multi-phones
- Statistical monitoring with DB server over LAN

GS-8000 Manufacturing Test System

Technical Issues in RF Parametric Test

Wide frequency range and wide dynamic range for source and analyzer

- **900 kHz (1 MHz) – 12.75 GHz for Spurious Emission and Blocking tests**

Accurate RF path loss calibration to manage measurement uncertainty

- **Bad RF path design results in difficulty calibrating out mismatch effects**
- **Managing and maintaining accurate loss factor**

A Complex test plan is required

- **Need to switch radio format and/or RF band within one test plan)**

Examples of Techniques Employed in Testing

In this paper, the following topics will be discussed…

Handover and Compressed Mode

- **Uplink Compressed Mode Measurement**

Re-configurable and complex RF signal routing

- **What kind of components are required ? What are key characteristics?**
- **Techniques to Check Stability or Health of the System**

New Frequency Assignment for W-CDMA in 800MHz Band (Band VI)

Band VI was newly assigned in 3GPP-FDD specification. This band was used for analog cellular, PDC, MCA, Tele-terminal, etc. 10MHz each for UL and DL.

Band	UL frequency	DL frequency	
I	1920 – 1980 MHz	2110 –2170 MHz	← Original IMT2000 band
II	1850 –1910 MHz	1930 –1990 MHz	← GSM band (PCS1900)
III	1710-1785 MHz	1805-1880 MHz	← GSM band (DCS1800)
IV	1710-1770MHz	2110- 2170MHz	← DCS1800+IMT2000
V	824 - 849MHz	869-894MHz	← GSM band (GSM850)
VI	830- 840 MHz	875-885 MHz	← JAPAN 800M band

Handover and Compressed mode

When Band I (IMT2000) and Band VI (UMTS800) coexist in service area, hard handover between frequency bands is required.

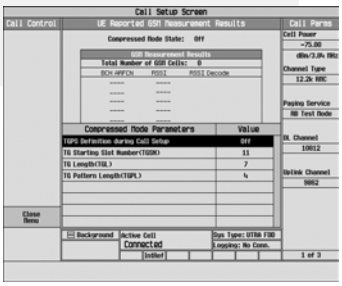
To find candidates of other carriers in different band, compressed mode technology is introduced.

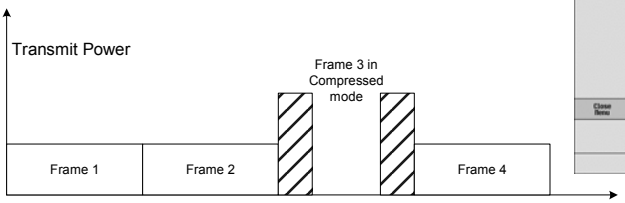
Compressed mode is also used for UMTS-FDD to GSM inter-system hard handover.

In the following session, we go through overview of handover technologies used in UMTS-FDD system. And then mechanism of compressed mode in hard handover is reviewed.

Hard Handover using Compressed mode

Compressed mode enables MAHO during hard handover
Gaps in UL and/or DL RF transmissions
Gaps (idle time) can be created by partially speed up data rate
UE performs measurements for MAHO during this idle time. Then UE can search other cell (W-CDMA or GSM)
There are three method for compressing data
- Spreading Factor Reduction
- Bit Puncturing
- Upper Layer Scheduling





Normal Frame and Compressed Frame

Handover related RF Performance Test Cases

Following handover related test cases are specified in 3GPP TS 34.121

5.7 Power Setting in uplink compressed mode (*) (**)

7.7.1 Demodulation of DCH in Inter-Cell Soft Handover (*)

7.7.2 Combining of TPC commands from radio links of different radio link sets (*)

7.9 Downlink compressed mode (*)

8.3.1 FDD/FDD Soft Handover (*)

8.3.2.1 FDD/FDD Hard Handover to intra-frequency cell (*)

8.3.2.2 FDD/FDD Hard Handover to inter-frequency cell (*)

8.3.3 FDD/TDD Handover

8.3.4 Inter-system Handover from UTRAN FDD to GSM

(*) : Agilent Z2195A UMTS-FDD RF Full Conformance System can test these test cases
(**) : Agilent GS-8800 RF Design Verification System will support this test case

Inter-system Handover from UTRAN FDD to GSM without compressed mode is supported by Agilent E5515C.

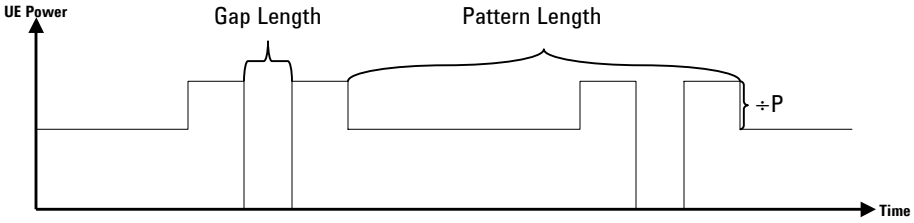
5.7 Power Setting in uplink compressed mode

This test case requires to measure UE transmit power behavior during three compressed mode frame patterns.

System simulator needs to provide three kind of compressed frame pattern with gap(s)

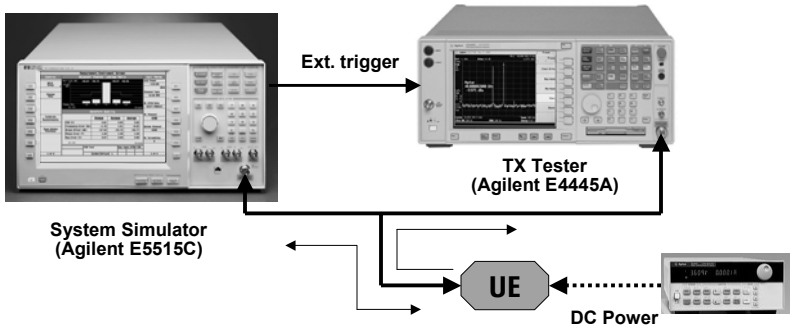
Measurement instrument (system) needs to measure uplink slot powers just before and after gap(s)

This sequence also includes detail UE power control (TPC) patterns



Uplink Compressed mode Measurement

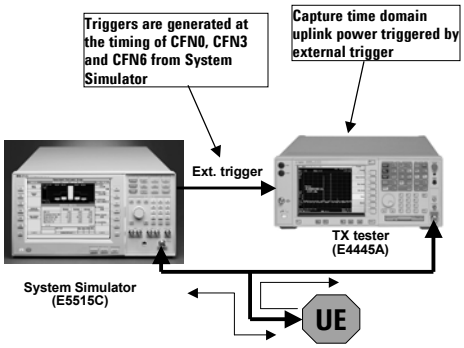
This block diagram is set up of "5.7 Power Setting in Uplink Compressed mode" measurement employed in Agilent GS-8800 RF Design Verification System



Measurement block diagram of Power Setting in Uplink Compressed mode

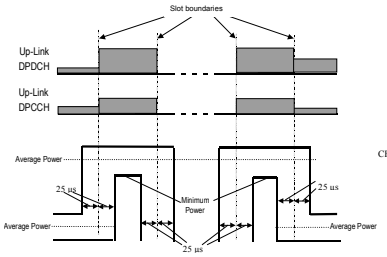
Uplink Compressed mode Measurement

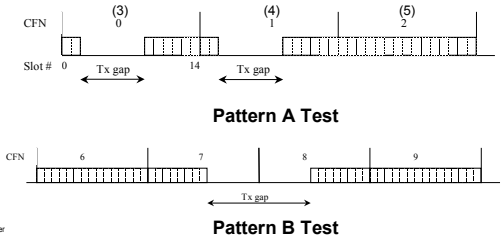
Overview of test sequence

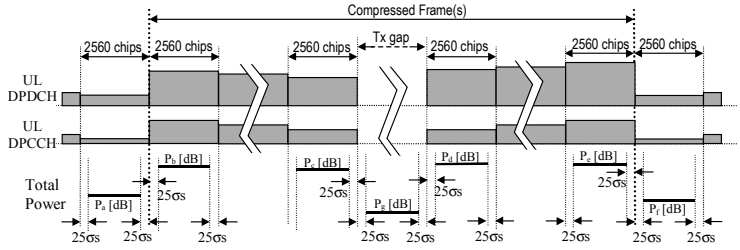

Triggers are generated at the timing of CFN0, CFN3 and CFN6 from System Simulator
Capture time domain uplink power triggered by external trigger
Ext. trigger
TX tester (E4445A)
System Simulator (E5515C)
UE

- SS establishes RMC12.2kbps loopback test mode (RB test mode) after call connection
- After UE TX power adjustment sequence, SS set up Pattern A compressed frame
- SS sends TPC commands for CFN0, 1 and 2 SS generates external trigger to TX tester at the timing of CFN0
- TX tester captures UL slot powers during CFN0,1 and 2
- Same measurements for CFN3, 4 and 5
- Same sequence for Pattern B (CFN6, 7, 8 and 9)

5.7 Power Setting in uplink compressed mode

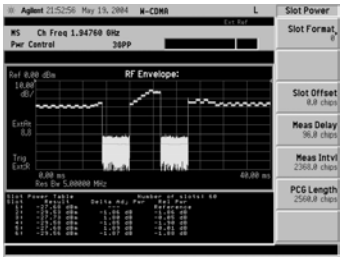




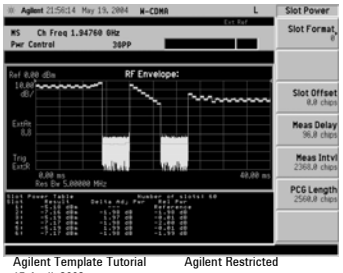


Actual Measurement Example of Uplink Compressed mode

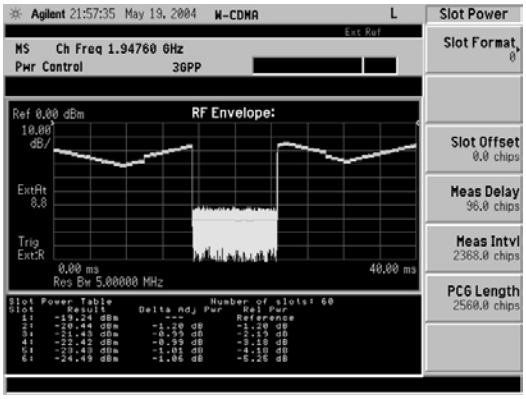
Pattern A Test (CFN0,1,2)
TPC:01-------11111111-------10101010101010101010



Pattern A Test (CFN3,4,5)
TPC:01-------00000000-------01010101010101010101

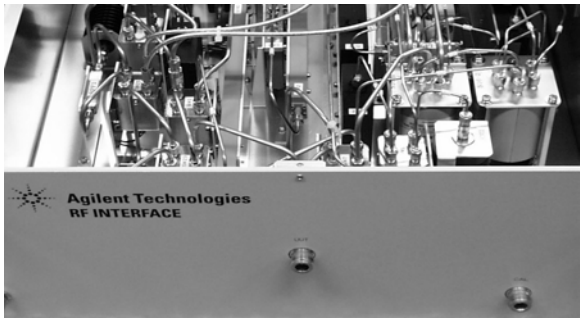


Pattern B Test (CFN6,7,8,9)
TPC:00000000000011111111111----------00000000000111111111111


Agilent 21:57:35 May 19, 2004 W-CDMA L
MS Ch Freq 1.94760 GHz
Pwr Control 3GPP
Ref 0.00 dBm
10.00 dB/
RF Envelope:
ExtAt 8.8
Trig ExtR
0.00 ms
Res Bw 5.00000 MHz
40.00 ms
Slot Power Table Number of slots: 60
Slot Result Delta Adj Pwr Rel Pwr
1: -19.24 dBm --- Reference
2: -20.44 dBm -1.20 dB -1.20 dB
3: -21.43 dBm -0.99 dB -2.19 dB
4: -22.42 dBm -0.99 dB -3.18 dB
5: -23.43 dBm -1.01 dB -4.19 dB
6: -24.49 dBm -1.06 dB -5.25 dB
Slot Power
Slot Format 0
Slot Offset 0.0 chips
Meas Delay 96.0 chips
Meas Intvl 2368.0 chips
PCG Length 2560.0 chips

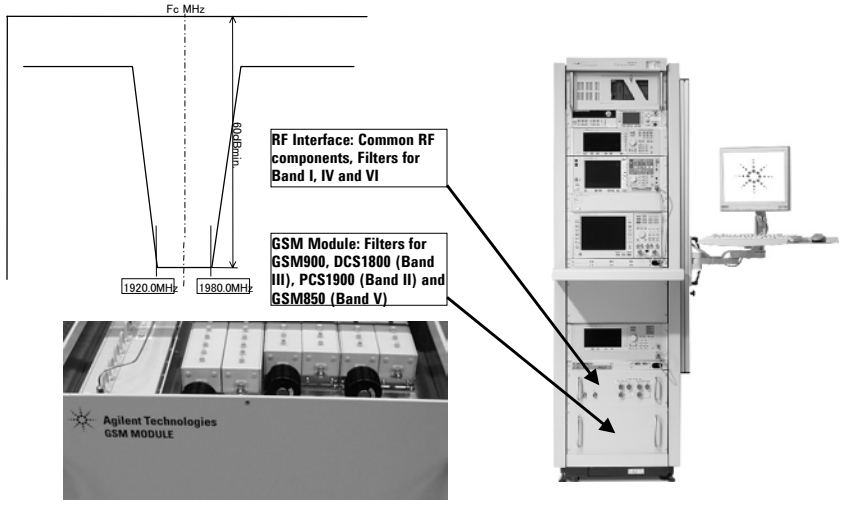
Re-Configurable and Complex RF Signal Routing

- **What kind of components are required ? What are key characteristics?**
- **Techniques to Check Stability or Health of the System**



UMTS-FDD Band II, III, IV, V and VI

GS-8800 is covering all UMTS-FDD bands (I ~ VI)


Fc MHz
60dBmin
1920.0MHz
1980.0MHz
RF Interface: Common RF components, Filters for Band I, IV and VI
GSM Module: Filters for GSM900, DCS1800 (Band III), PCS1900 (Band II) and GSM850 (Band V)
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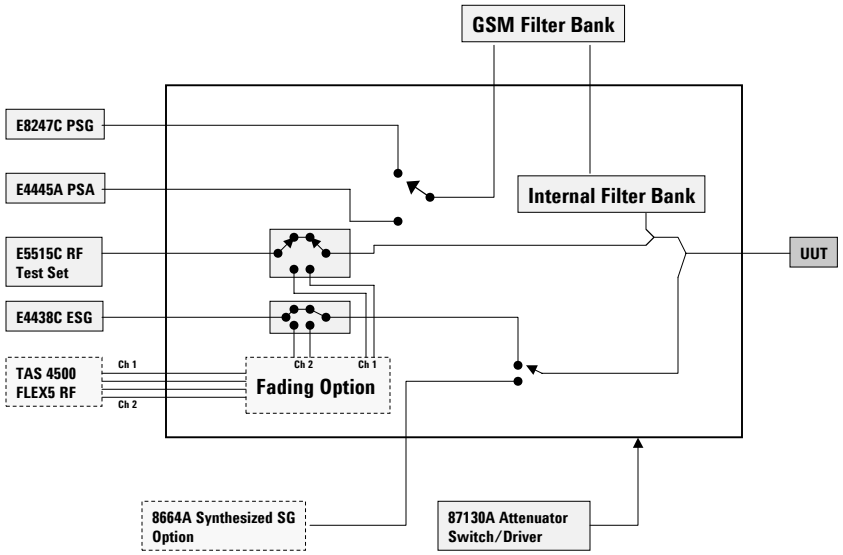
GSM MODULE

RF Interface

- **DUT connections automation**
  - Simplifies operation
  - Speeds up testing
  - Ensures better repeatability
  - Reduce risk of connection error
- **Modular design approach**
  - Single box holds base RF filters and switching except GSM/GPRS
  - Optional GSM/GPRS filter box RF Fading Simulation
  - module for currently implemented cellular formats
- **Loop-back path for loss calibration**
  - Optimized RF path loss calibration

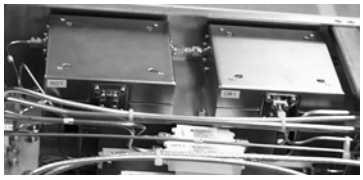
RF Interface: Conceptual Diagram



What kinds of Components need to Establish Paths which have Wide Frequency Range for In/Out Band Test

Be careful of band-limited devices in these paths or switch out them during measurements

- **Combiners / Dividers / Couplers**
- **Isolators / Circulators**
- **Filters**
- **Mixers / Amplifiers**
- **Sometimes also Attenuators and Switches**



Path loss must be as low as possible

- **Design path mechanical length to be as short as possible**
- **Low loss microwave coaxial connectors and cables must be used**

System RF Path Loss Management from 9kHz to 12.75GHz

Requirements from standard core specification

- **W-CDMA FDD case (3GPP TS 25.101, Release 1999)**
  - **Spurious emissions (6.6.3) : 9 kHz – 12.75 GHz**
  - **Blocking (7.6) : 1 MHz – 12.75 GHz**
- **GSM case (3GPP TS 05.05, Release 1999)**
  - **Spurious emissions (4.3) : 9 kHz – 12.75 GHz**
  - **Blocking (5.1) : 100 kHz – 12.75 GHz**
- **cdma2000 case (3GPP2 C. S0011-A)**
  - **Spurious emissions (4.5.1) : 9 kHz – 12.75 GHz**
  - **Blocking (3.5.5) : 1 MHz – 12.75 GHz**

It's not so easy!

E9304A #H18 Power Sensor 9 kHz – 18 GHz

Good System Hardware Design is the First Step of Calibration

Make measurement system as clean as possible

- **Good frequency response**
- **Low reflection coefficients (VSWR)**
- **Good stability**

Calibration only as good as hardware stability

Calibration can't make up for poor system design

This slide was originally created for "Microwave System Design Methodology" training in 1997

Last Feet is the Most Important, though

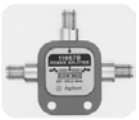
Fixturing and characterization of fixture are very important

- Use good RF coaxial cable
  - Poor fixture/cable will make all calibration effort meaningless
- As short as possible
  - Ideally use only an adaptor for commercial RF connector
  - Because it is normally difficult to measure fixture cable loss

Select Low Loss and High Isolation Combiners/Dividers

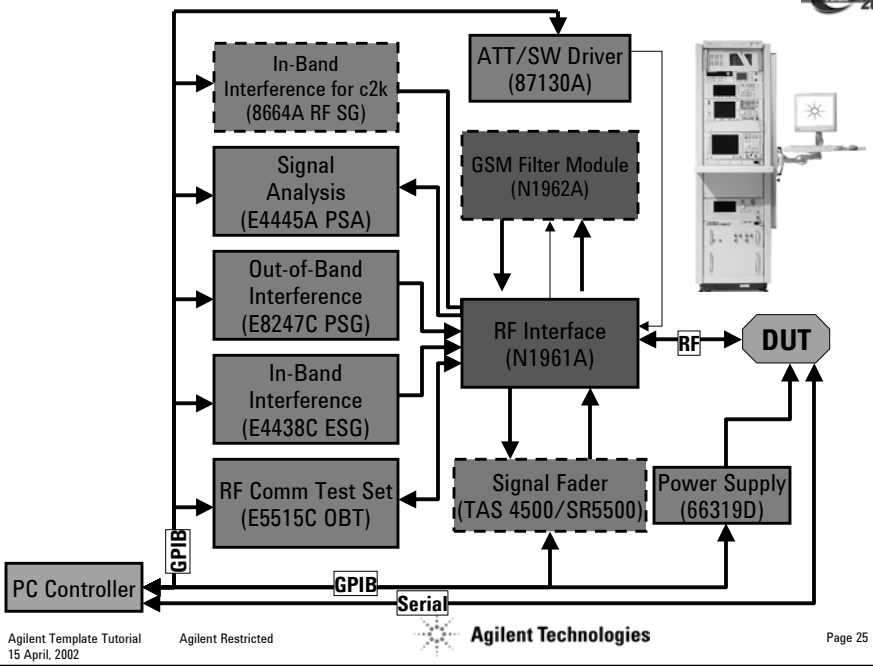
High loss combiners/dividers will result in poor dynamic range of uplink measurements and downlink signal level

- Wilkensen type combiner/divider
  - Low loss (approx. 1 dB above split)
  - Good isolation
  - Moderate bandwidth
- 2 resistor type or 3 resistor type
  - Lossy (>3 dB above split)
  - Bad isolation
  - Wide bandwidth (down to DC)



This slide was originally created for "Microwave System Design Methodology" training in 1997

GS-8800 System Hardware



GS-8800 Test Case Coverage

3GPP TS 34.121 Section Number	Test Description	Tested	Comments	8960 E5515C	LA?	PSA E444xA	PSG E8247C	ESG E4438C	Fading SR5500 (TAS4500)
	W-CDMA Transmitter Tests								
5.2	Maximum Output Power (Thermal and CH power)	Yes		x					
5.3	Frequency Error	Yes		x					
5.4.1	Open Loop Power Control in the Uplink	Yes		x					
5.4.2	Inner Loop Power Control in the Uplink	Yes		x					
5.4.3	Minimum Output Power	Yes		x					
5.4.4	Out-of-synchronization handling of output power	Yes*	Planned in Oct/04	x	x	x			
5.5.1	Transmit OFF Power	Yes		x					
5.5.2	Transmit ON/OFF Time mask	Yes		x					
5.6	Change of TFC	Yes*	Planned in Sep/04	x	x				
5.7	Power Setting in uplink compressed mode	Yes*	Planned in Oct/04	x	x	x			
5.8	Occupied Bandwidth (OBW)	Yes		x					
5.9	Spectrum emission mask	Yes		x					
5.10	Adjacent Channel Leakage Power Ratio (ACLR)	Yes		x					
5.11	Spurious Emissions	Yes		x		x			
5.12	Transmit Intermodulation	Yes		x		x	x		
5.13.1	Error Vector Magnitude (EVM)	Yes		x					
5.13.2	Peak code domain error	Yes*	*12.2k/64k/384kbps but not 768kbps	x					
5.13.3	UE Phase Discontinuity	Yes		x					
5.13.4	PRACH Preamble Quality	Yes		x	x				
	W-CDMA Receiver Tests								
6.2	Reference Sensitivity Level	Yes		x					
6.3	Maximum Input Level	Yes		x					
6.4	Adjacent Channel Selectivity (ACS)	Yes		x				x	
6.5	Blocking Characteristics	Yes		x			x	x	
6.6	Spurious Response	Yes		x			x		
6.7	Intermodulation Characteristics	Yes		x			x	x	
6.8	Spurious emissions	Yes	Cell FACH mode	x	x	x			
	W-CDMA Performance Requirement Tests								
7.2.1	Demodulation of Dedicated Channel (DCH)	Yes*	64k,144k and 384k is planned in Sep/04	x					
7.3	Demodulation of DCH in Multi-path Fading Propagation conditions	Yes*	64k,144k and 384k is planned in Sep/04	x			(x)	(x)	x
7.4	Demodulation of DCH in Moving Propagation conditions	Yes*	64k,144k and 384k is planned in Sep/04	x			(x)	(x)	x
7.5	Demodulation of DCH in Birth-Death Propagation conditions	Yes*	64k,144k and 384k is planned in Sep/04	x			(x)	(x)	x

Specification subjects to change.

GS-8800 GCF W-CDMA Validation Schedule

TS 34.121 v5.2.0	Category	Test name	Validation target
5.2	A	Maximum Output Power (Thermal and CH power)	Sep/04
5.3	A	Frequency Error	Sep/04
5.4.1	A	Open Loop Power Control in the Uplink	Sep/04
5.4.2	A	Inner Loop Power Control in the Uplink	Sep/04
5.4.3	A	Minimum Output Power	Sep/04
5.4.4	A	Out-of-synchronization handling of output power	Jan/05
5.5.1	N/A	Transmit OFF Power	X
5.5.2	A	Transmit ON/OFF Time mask	Sep/04
5.6	A	Change of TFC	Jan/05
5.7	P	Power Setting in uplink compressed mode	Jan/05
5.8	A	Occupied Bandwidth (OBW)	Sep/04
5.9	A	Spectrum emission mask	Sep/04
5.10	A	Adjacent Channel Leakage Power Ratio (ACLR)	Sep/04
5.11	A	Spurious Emissions	Sep/04
5.12	A	Transmit Intermodulation	Sep/04
5.13.1	A	Error Vector Magnitude (EVM)	Sep/04
5.13.2	P	Peak code domain error	-
6.2	A	Reference Sensitivity Level	Sep/04
6.3	A	Maximum Input Level	Sep/04
6.4	A	Adjacent Channel Selectivity (ACS)	Sep/04
6.5	A	Blocking Characteristics	Sep/04
6.6	A	Spurious Response	Sep/04
6.7	A	Intermodulation Characteristics	Sep/04
6.8	A	Spurious emissions	Sep/04
7.2.1	A	Demodulation of Dedicated Channel (DCH)	Jan/05
7.3.1	A	Demodulation of DCH in Multi-path Fading Propagation conditions	Mar/05
7.4.1	A	Demodulation of DCH in Moving Propagation conditions	Mar/05
7.5.1	A	Demodulation of DCH in Birth-Death Propagation conditions	Mar/05

GCF Certification Target

- Current available test cases: Sep/2004

- Test cases available in Oct:: Jan/2005

- Test cases available in Dec: Mar/2005

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